Magnetic Properties of Uncompensated Spins in Co/NiO

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BACKGROUND

The investigation of magnetic multilayers is an active research area, driven by the interesting physics associated with such structures and their application in the magnetic storage industry. While the interface itself is supposed to dominate the magnetic behavior of the entire system, the identification and characterization of its magnetic properties remains an experimental challenge. A prominent example is the so called exchange bias effect, which is the directional coupling between the spins in an antiferromagnet and those in an adjacent ferromagnet, for a review see [1]. An important parameter in modelling the exchange bias effect are possible uncompensated spins in the antiferromagnet. Recently, we demonstrated the existence of uncompensated Ni spins in the Co/NiO system with XMCD [2] and PEEM [3] measurements and related them to an oxidation/reduction effect at the interface. Here we present hysteresis loops of exchange biased Co/NiO multilayer measured with X-ray absorption spectroscopy (XAS). The experiment was performed at the elliptically polarizing undulator beamline 4.0.2 of the Advanced Light Source, USA.

RESULTS

The sample studied was a multilayer of 3 nm Co and 50 nm NiO grown on Si. The surface (Co on top) was capped with a 1.5 nm Ru layer to prevent its oxidation. The easy axis of the Co layer was in the plane of the sample and an exchange bias field of 175 Oe was obtained. The XAS spectra were measured in the absorption mode by measuring the sample current. The sample was mounted in grazing incidence in the gap

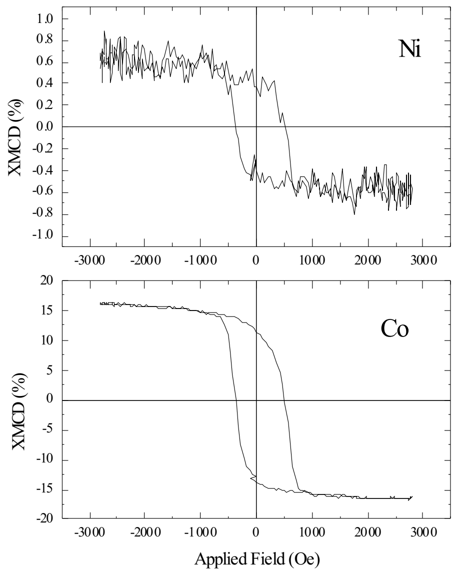

Figure 1: Hysteresis loops of ferromagnetic Co and interfacial ferromagnetic Ni. The Ni signal arises from an equivalent of 0.5ML buried below 4nm of Co and Ru. The loops show no qualitative differences within the error of the experiment.

of an electromagnet, which can switch a magnetic field up to 3000 Oe with 1 Hz and has the magnetic field along the polarization vector of the circularly polarized light. The hysteresis loop for Ni is measured as follow. The magnetic field is varied from -3000 Oe to +3000 Oe and back in 50 Oe steps. At each magnetic field the absorption signal at the L_3 and L_2 edge for a fixed polarization is measured. Next the measurement is repeated with opposite polarization. The hysteresis loop is calculated by taking the ratio of both polarizations for each edge and then calculating the difference between L_3 and L_2 loop. The hysteresis loop for Co is obtained in the same way.

Within the experimental error there are no differences between the Co and the Ni loop. A final decision whether all interfacial spins rotate in the external field together with the Co spins or a small fraction of them remains *pinned* to introduce the unidirectional anisotropy cannot be made. This is due to the fact that the vertical position of the loops is slightly influenced by experimental factors and the absolute zero line has to be determined by a reference measurement with an unbiased sample. However we estimate the amount of pinned moments to be less than 20%. A more accurate investigation is currently underway. Nevertheless the determination of element specific hysteresis loops with excellent depth sensitivity and the ability to pick up the magnetic signal arising from small amount of buried material is a promising first result.

References

[1] J. Noguès and I.K. Schuller, J. Magn. Magn. Mater. 192, 203 (1999).

[2] F. Nolting, E. Arenholz, A.T. Young, A. Scholl, H. Ohldag, and J. Stöhr, ALS Compendium, 2000, LBNL publication, 47838.

[3] H. Ohldag, T. J. Regan, J. Stöhr, A. Scholl, F. Nolting, J. Lüning, C. Stamm, S. Anders, and R. L. White, Phys. Rev. Lett. 87, 247201 (2001).

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